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The LIFE Project "Monitoring of insects with public participation" (MIPP): aims, methods and conclusions

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Abstract

The Life Project "Monitoring of insects with public participation" (LIFE11 NAT/IT/000252) had as the main objective to develop and test methods for the monitoring of five beetle species listed in the Annexes of the Habitats Directive (92/43/EEC): *Osmoderma eremita* (hermit beetle, Scarabaeidae), *Lucanus cervus* (European stag beetle, Lucanidae), *Cerambyx cerdo* (great capricorn beetle, Cerambycidae), *Rosalia alpina* (rosalia longicorn, Cerambycidae) and *Morimus asper/funereus* (morimus longicorn, Cerambycidae). The data gathered represent an important contribution to the monitoring of these target species in Italy. The methods developed for monitoring of the target species are intended for use by the local management authorities and staff of protected areas. These developed methods are the result of extensive fieldwork and ensure scientific validity, ease of execution and limited labour costs. The detailed description of methods and the results for each species are published in separate articles of this special issue of Nature Conservation. A second objective of the project was to gather faunistic data with a Citizen Science approach, using the web and a mobile application software (app) specifically built for mobile devices. The validation of the records

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collected by the citizens was carried out by experts, based on photographs, which were obligatory for all records. Dissemination activities represented the principal way to contact and engage citizens for the data collection and also offered the possibility of providing information on topics such as Natura 2000, the Habitats Directive, the role of monitoring in nature conservation, the importance of forest ecosystems and the ecological role of the saproxylic insects. An innovative method tested during the project was the training of a dog for searching and monitoring the elusive hermit beetle; the trained dog also added a "curiosity" factor to attract public attention towards this rare insect and the issues mentioned above.

Keywords
Saproxylic beetle monitoring, Insect conservation, Forest biodiversity, Habitats Directive, Citizen Science, LIFE Nature Project

Introduction

Monitoring biodiversity and habitats directive

The inaugural meeting of the International Union for Protection of Nature (IUPN, later renamed IUCN), held in 1948, began to set up instruments to monitor the status of animals and plants worldwide. Over subsequent years, the monitoring of habitats and species became a core activity of nature conservation across the planet and an important chapter of conservation biology (Goldsmith 1991, Elzinga et al. 2001, Marsh and Trenham 2008, Schmeller 2008). Species monitoring is the regular observation and recording of changes in status and trend of species in a certain territory (Kull et al. 2008). The major aim of monitoring is to collect information that can be used for conservation policy, to examine the outcomes of management actions and to guide future management decisions (Kull et al. 2008). It consists of collecting reliable data which in turn allow the researchers to draw conclusions that species and ecosystems are changing their status through time and space, either naturally or as a consequence of deliberate or unintentional human intervention. It is often applied to assess the status of threatened species, the spread of alien or invasive species, the health of ecosystems, the efficacy of protected areas and other conservation actions. In any case, monitoring programmes should be focused on providing precisely the information needed to make the right conservation decisions. Therefore, the formulation of clear and explicit monitoring objectives is a key first step in the planning of any wildlife monitoring programme (Elzinga et al. 2001, Yoccoz et al. 2001, Williams et al. 2002, Noon 2003, Lindenmayer and Likens 2010, Legg and Nagy 2006, Nichols and Williams 2006; Martin et al. 2007). It should be kept in mind that there is no "best" survey method that suits all purposes, and is efficient, precise, reliable, simple and cheap at the same time. The suitability of a method may depend on the local circumstances, as environmental features, budget and the number of volunteers involved.

Monitoring programmes range from small scale, local programmes, to large-scale, national and international programmes (Schmeller et al. 2012), and from simple field

surveys to complex procedures which require a considerable budget to cover staff costs, as well as expensive material and equipment. Moreover, governmental and local budgets allocated to biodiversity conservation are often scarce, and gathering data exclusively by professionals may not be possible. The management authorities often turn to volunteers, such as local naturalists coordinated by a small team of professionals. In these cases, citizen science offers an additional way for the monitoring of living organisms (Chandler et al. 2017, McKinley et al. 2006, Lindenmayer and Likens 2010). In any case, every effort should be made to involve local people and organisations in monitoring, as they have a vested interest in the areas and the species concerned. Involving local volunteers in a project can bring out questions, ideas and techniques that might not otherwise surface (McKinley et al. 2006). The Council Directive 92/43/EEC, better known as the Habitats Directive and adopted by the European Community in 1992, is focused on the conservation of natural habitats, flora and fauna. Its aim is to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements. Together, the Habitats Directive and the Birds Directive (79/409/CEE) comprise the cornerstone of Europe's nature conservation policy and they established the EU wide Natura 2000 ecological network of protected areas which are safeguarded against potentially damaging developments (http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm). This network, in 2011 accounted for over 26,400 sites with a total surface area of about 986,000 km^2, comprising nearly 768,000 km^2 of land. The terrestrial component of the network represents 17.9 % of the surface area covered by the EU 27 countries.

The Habitats Directive, which has gone through a number of updates and corrections, mainly to the annexes, ensures the conservation of a wide range of rare, threatened or endemic animal and plant species (as listed in Annex II, IV and V), as well as some 200 rare and characteristic habitats (as listed in Annex I). The current species lists in Annexes II and IV have a dominant proportion of vertebrates and very few arthropods (of which only eleven are priority species) (Cardoso 2012). Additionally, it must be noted that many emblematic, endemic and threatened insect species of southern Europe do not figure in the Habitats Directive (e.g., the renowned Italian moth *Brahmaea* (*Acanthobrahmaea*) *europaea* Hartig, 1963 (cf. Mosconi et al. 2014). All of these observations suggest an urgent need for updating and revision of the Habitats Directive.

Monitoring of conservation status is an obligation arising from Article 11 of the Habitats Directive for all habitats and species of Community interest. Consequently, this provision is not restricted to Natura 2000 sites and data should be collected both in and outside the Natura 2000 network to achieve a full assessment of the conservation status of the species. The main results of this monitoring should be reported to the Commission every six years according to Article 17 of the Directive. In Italy, as in many other countries, population trends for most of the insect species listed in the Annexes are currently unknown as coordinated monitoring programmes are lacking (Genovesi et al. 2014, Carpaneto et al. 2015, Stoch and Genovesi 2016).

The saproxylic organisms

Saproxylic organisms depend on decaying wood of moribund or dead trees (standing or fallen), or upon the presence of other saproxylic species at least during some phases of their life-cycle (Speight 1989, Alexander 2008). On the whole, saproxylic organisms (especially saproxylic insects) account for a considerable part of forest biodiversity (Stokland et al. 2012). The percentage values of saproxylic species, with respect to other living organisms, vary in different environmental contexts, e.g., 10% of all living organisms in Scandinavia (Stokland et al. 2012), 30% of forest species in Germany (Müller et al 2008) and probably more in southern European countries (Carpaneto et al. 2015). Many saproxylic species (saproxylophagous species) depend upon decaying woody material (dead wood) as a nutrition source but others are predators and parasitoids of saproxylophagous insects and of other animals that use wood as a breeding site or refuge, as well as fungi, mosses and lichens on the surface of dead wood (Stokland 2012, Stokland et al. 2012, Carpaneto et al. 2015).

The order Coleoptera is the most species rich taxon worldwide and gives a relevant contribution to saproxylic biodiversity (Brunet and Isacsson 2009). Thus, saproxylic beetles are one of the most important components of forest ecosystems and play a key role in nutrient cycling and ecosystem functioning (Stokland 2012). Consequently, their abundance, richness and diversity depend on the availability of food resources linked to mature forest habitats (Redolfi De Zan et al. 2014a). It has been shown that forest management practices, which increase the amount and variety of dead wood, benefit saproxylic beetles as well as other indicators for the conservation status of forests such as hole-nesting birds (Hardersen 2003, Redolfi De Zan et al. 2014b). In particular, a direct correlation likely exists between diversity and abundance of saproxylic beetles and of specialised insectivore birds that feed on them, such as hole-nesting birds (Redolfi De Zan et al. 2014b).

As European forests have suffered from intensive wood exploitation by man for several centuries, most of the managed forests contain very little dead wood and low levels of biodiversity. Nevertheless, a slight increase in both deadwood and biodiversity has been observed in the last decades, probably due to the current policies of environmental protection in European countries (Vallejo 2015). For example, primeval beech forests in the Ukrainian Carpathians harbour the highest volumes of dead wood, from 147 to 181 m^3/ha (Commarmot et al. 2013), whereas managed beech forests in Italy have only 7.6 m^3/ha (Gasparini and Tabacchi 2011). Generally, the estimates for standing and lying deadwood in European forests range between 5 and 15 m^3/ha for most countries (Vallejo 2015). Restoration of functional saproxylic communities is not an easy task because the addition of dead wood to a forest does not necessarily lead to recolonisation by all saproxylic insects. In fact, saproxylic species need different quantity and quality of dead wood, characterised by a structural heterogeneity and various degrees of biodegradation (Stokland et al. 2012, Parisi et al. 2016). Moreover, many saproxylic beetles have limited dispersal abilities (Fayt et al. 2006; Buse 2012), whereas some species cannot fly at all (e.g. *Morimus*) and tend to aggregate in small areas. As a

consequence, forests with a recent accumulation of dead wood are inhabited by fewer red-listed species than forests with an uninterrupted history of dead wood abundance (Nilsson and Baranowski, 1997). The continuity of deadwood availability plays a major role for many saproxylic beetles, as sensitive species may disappear from cultivated forests where traditional management has been interrupted or changed, e.g. from pollarding to coppicing (Müller et al. 2005, Dubois 2009). Thus, the conservation status of saproxylic beetles and the species richness of their communities cannot be inferred directly from the amount of dead wood currently present. The conservation of saproxylic insects is also pursued in managed forests by applying particular management methods, such as "retention forestry" (Lindenmayer and Franklin 2002), the "îlots de sénescence" [senescence islands] (Lachat and Bütler 2008), "forest biodiversity artery" (Mason and Zapponi 2015) or by artificially increasing dead wood (Cavalli and Mason 2003, Zapponi et al. 2014).

Many factors are threatening saproxylic insects, particularly the large saproxylic beetles (LSB), such as stag beetles, hermit beetles and other fruit chafers, rosalia and great capricorn, to which this special issue and the MIPP project were dedicated. These species, owing to their great body size, need a larger volume of dead wood in aggregate form, i.e. in the same tree, for successful larval development. Consequently, their body size limits the abundance of their populations and makes them easily detectable by mammal and bird predators as well as by people. The major threats to saproxylic beetles are the fragmentation and/or structural simplification of woodlands, as well as the loss of suitable microhabitats. In particular, the so called habitat trees, i.e. standing live or dead trees represent a fundamental resource for saproxylic beetles, providing ecological niches and microhabitats, such as cavities, bark pockets, large dead branches, cracks, sap runs or trunk rot (Gibbons and Lindenmayer 2002, Cavalli and Mason 2003, Bütler et al. 2013). In particular, for LSB, the possible threats suggested by some of us according to our personal experience and in order of decreasing importance, are the following: the decreasing density of old trees (especially hollow trees) from forests due to commercial management, the old-growth forest fragmentation, the eradication of old tree rows from agricultural landscapes, the changes in tree management with the abandonment of pollarding, the spread of pesticides against invasive moths or other pests and the removal of old trees used as biomass for industrial fuel production. In some European countries or areas, other factors can represent a threat such as: the increasing drought in forest soils due to intensive groundwater exploitation (especially in Mediterranean areas), the demographic escalation of predators of large insects (especially crows), beetle killing by increased car traffic in summer months on roads crossing forested areas or stretching along the forest edge, the commercial exploitation of beetles by insect dealers for collectors and the deliberate killing of adult beetles in woodlands near to human settlements (especially for stag beetle males and great capricorn). The combination of threats currently facing LSB requires immediate conservation actions at various levels from site-level initiatives, through national and regional strategies, to international conventions and action plans. Baseline density estimates and subsequent monitoring of LSB populations are essential for assessing the

impacts of particular threats and measuring whether conservation programmes are succeeding. Therefore, the conservation of LSB requires a detailed understanding of their population size, spatial distribution and demographic trends. Seibold et al. (2015) showed that the saproxylic beetles which face a higher extinction risk are: large-sized species, lowland forest-dwelling species, open canopy species and species that rely on large diameter, broad-leaved trees. However, quantitative data for many species are still lacking and their conservation status is poorly known, both of which are due to their elusive nature (Bouget et al. 2008, Seibold et al. 2015), the restricted daily and seasonal activity of the adults (e.g. Drag et al. 2011, Campanaro et al. 2016), the low density of their populations (e.g. Castro and Fernández 2016) and the scarcity of researchers involved in their ecological study (Haslett 2007, Hochkirch 2016). All these factors together, combined with the current scarcity of suitable habitats, are reasons why the implementation of efficient monitoring programmes is notoriously difficult.

The first methods for monitoring some LSB in Italy were published by Campanaro et al. (2011), while Trizzino et al. (2013) were the first to propose a review of the existing standard monitoring protocols for all arthropods listed in the Habitats Directive and occurring in Italy. A recently published manual provided methods and protocols for the monitoring of all species and habitats of community interest occurring in Italy (Stoch and Genovesi 2016). However, the methods so far proposed for these insect species are not based on a comparative approach tested in different nature reserves.

The Project Life MIPP: aim and objectives

The Life Project "Monitoring of insects with public participation" (LIFE11 NAT/IT/000252) (hereafter: MIPP) started on 1/10/2012 and will end in 30/09/2017 (Mason et al. 2015). The coordinating beneficiary of the project is the Comando Unità per la Tutela Forestale, Ambientale e Agroalimentare Carabinieri (hereafter: CUTFAA) (formerly: Corpo Forestale dello Stato), in particular the National Centre for the Study and Conservation of Forest Biodiversity Carabinieri "Bosco Fontana", Marmirolo, Mantova. Associate beneficiaries of MIPP are: the Council for Research in Agriculture and Analysis of Agrarian Economy, Cascine del Riccio - Firenze; the Sapienza University of Rome, Department of Biology and Biotechnologies "Charles Darwin"; the Roma Tre University, Department of Science; the Italian Ministry of the Environment and Protection of Land and Sea, General Direction for Protection of Nature and Sea; and the Lombardy Region (DG Ambiente, energia e sviluppo sostenibile).

The MIPP Project had, as first objective, to develop and test methods for the monitoring of five species of saproxylic beetles listed in Annexes II and IV of the Habitats Directive: *Lucanus cervus* (Linnaeus, 1758), *Osmoderma eremita* (Scopoli, 1763), *Cerambyx cerdo* Linnaeus, 1758, *Rosalia alpina* (Linnaeus, 1758) and the complex *Morimus asper asper* (Sulzer, 1776) / *Morimus asper funereus* Mulsant, 1863. The guidelines presented in separate contributions of this special issue of Nature Conservation are the result of extensive fieldwork carried out in order to develop readily standardised methods which

ensure scientific validity, ease of execution and limited labour costs for monitoring the above mentioned species. These methods were developed for use by local management authorities, staff of protected areas and the conservation community at large, to gather raw data for assessing the status of the species every six years. The standardised methods developed by the MIPP staff resulted in quantitative data collected from various sites, using traps and/or lures, mark-recapture techniques, transects and, in some cases, genetic analyses. For *Osmoderma eremita*, the most elusive of these species, a dog was trained to search for the larvae of this beetle. In the last few decades, conservation dogs have been used for an array of activities, including detection of a large variety of taxonomic groups (Mosconi et al. (2017). In many cases, these dogs resulted in being more efficient than other survey methods in detecting the target species (Beebe et al. 2016). Many of the large and protected saproxylic beetles are cryptic (Bouget et al. 2008, Seibold et al. 2015) but in the case of *O. eremita* detection is also difficult due to its elusive nature, i.e. its limited daily activity (Le Gouar et al. 2015). Therefore it was decided to train a dog to find this protected beetle. The conservation dog of the MIPP subproject "Osmodog" is the first to be trained for an endangered beetle species.

A second objective of the project was to apply a Citizen Science approach (Zapponi et al. 2016) to increase the current knowledge of the regional and ecological distribution of nine species of insects protected by the Habitats Directive, i.e. the five beetles selected for monitoring and four additional species belonging to other two insect orders: *Saga pedo* Pallas, 1771, *Lopinga achine* (Scopoli, 1763), *Parnassius apollo* (Linnaeus, 1758) and the complex *Zerynthia cassandra* (Geyer, 1828) / *polyxena* (Denis and Schiffermüller, 1775). The first species belongs to the Order Orthoptera, the other three to Lepidoptera. By means of the citizen science approach, data were collected using a dedicated homepage of the web-site and an application for mobile device (app), while validation of the records based on photographs was carried out by experts.

A relevant component of the project was dissemination and communication which were used to inform people on issues such as Natura 2000, the Habitats Directive, the monitoring activities and the ecological role of the saproxylic insects within the forest ecosystems. The dog trained for the monitoring of the hermit beetle, was also used as a "curiosity" factor to attract public attention towards this rare beetle and the issues mentioned above.

Methods

Target species

The target taxa selected for the MIPP Project are listed in Table 1, together with an updated taxonomic arrangement, references to the Annexes of the Habitats Directive where they are included, and the MIPP objectives in which they were involved.

As deduced from Table 1, the taxonomic situation of the genera *Zerynthia*, *Osmoderma* and *Morimus* has varied in comparison with that which occurred in the

Table 1. Target taxa (species and subspecies) of the MIPP Project, with indications on: taxonomic arrangement (valid scientific names, author and year of description, order and family to which taxa are currently assigned); Annexes of the Habitats Directive where the taxa are listed (II and/or IV); MIPP objectives where taxa were involved (CZ: Citizen Science; TM: test of monitoring methods); study areas where monitoring methods have been tested for saproxylic taxa (BF: Bosco della Fontana, BM: Bosco della Mesola, FC: Foreste Casentinesi, PA: Parco Nazionale d'Abruzzo, Lazio e Molise, PG: Parco Naturale Regionale delle Prealpi Giulie).

Taxon, author and year of description	Order	Family	Annex HD	MIPP objectives	Study areas
Saga pedo Pallas, 1771	Orthoptera	Tettigoniidae	IV	CZ	
Parnassius apollo (Linnaeus, 1758)	Lepidoptera	Papilionidae	IV	CZ	
Zerynthia cassandra (Geyer, 1828) *Zerynthia. polyxena* (Denis and Schiffermüller, 1775)	Lepidoptera	Papilionidae	IV	CZ	
Lopinga achine (Scopoli, 1763)	Lepidoptera	Nymphalidae	IV	CZ	-
Lucanus cervus (Linnaeus, 1758)	Coleoptera	Lucanidae	II	CZ, TM	BF, FC
Osmoderma eremita eremita (Scopoli, 1763) *Osmoderma eremita italicum* Sparacio, 2000 *Osmoderma cristinae* Sparacio, 1994	Coleoptera	Scarabaeidae	*II, IV	CZ, TM	PA, FC
Cerambyx cerdo Linnaeus, 1758	Coleoptera	Cerambycidae	II, IV	CZ, TM	BF, BM
Rosalia alpina (Linnaeus, 1758)	Coleoptera	Cerambycidae	*II, IV	CZ, TM	PA, FC
Morimus asper asper (Sulzer, 1776) *Morimus asper funereus* Mulsant, 1863	Coleoptera	Cerambycidae	II	CZ,TM	BF / PG

*priority species

original Annexes of the Directive, due to some changes being made to systematics in consequence of morphological and molecular studies. Either *Zerynthia polyxena* or *Osmoderma eremita* have been divided into two species, while *Morimus funereus* was downgraded to a subspecies of *Morimus asper*. Moreover, the *Osmoderma* populations of southern Italy (Campania, Basilicata and Calabria regions) were assigned to a new subspecies, *O. eremita italicum*. Therefore, the Italian populations of *Osmoderma* now include two subspecies of *O. eremita* and a valid species endemic to Sicily, *O. cristinae*.

The saproxylic beetles (*Lucanus*, *Osmoderma*, *Cerambyx*, *Rosalia* and *Morimus*) have been used for both the main objectives of the project: 1) the definition of a standardised method for the monitoring of the species in Europe, in agreement of the criteria identified in the former chapter and 2) the collection of data on their distribution, altitude and phenology in Italy, through a Citizen Science approach. On the contrary, the butterflies (*Parnassius*, *Zerynthia* and *Lopinga*) and the bush cricket (*Saga pedo*) were used only for the second objective. Details of the Citizen Science approach are given by Campanaro et al. (2017b).

The target species of saproxylic beetles were selected as they share the following characteristics: (1) are listed in the Annexes II and/or IV of the Habitats Directive, (2) have a large body size, (3) are relatively easy to identify, (4) lack well tested monitoring methods, (5) depend on dead wood for completing their life cycle and (6) live in dif-

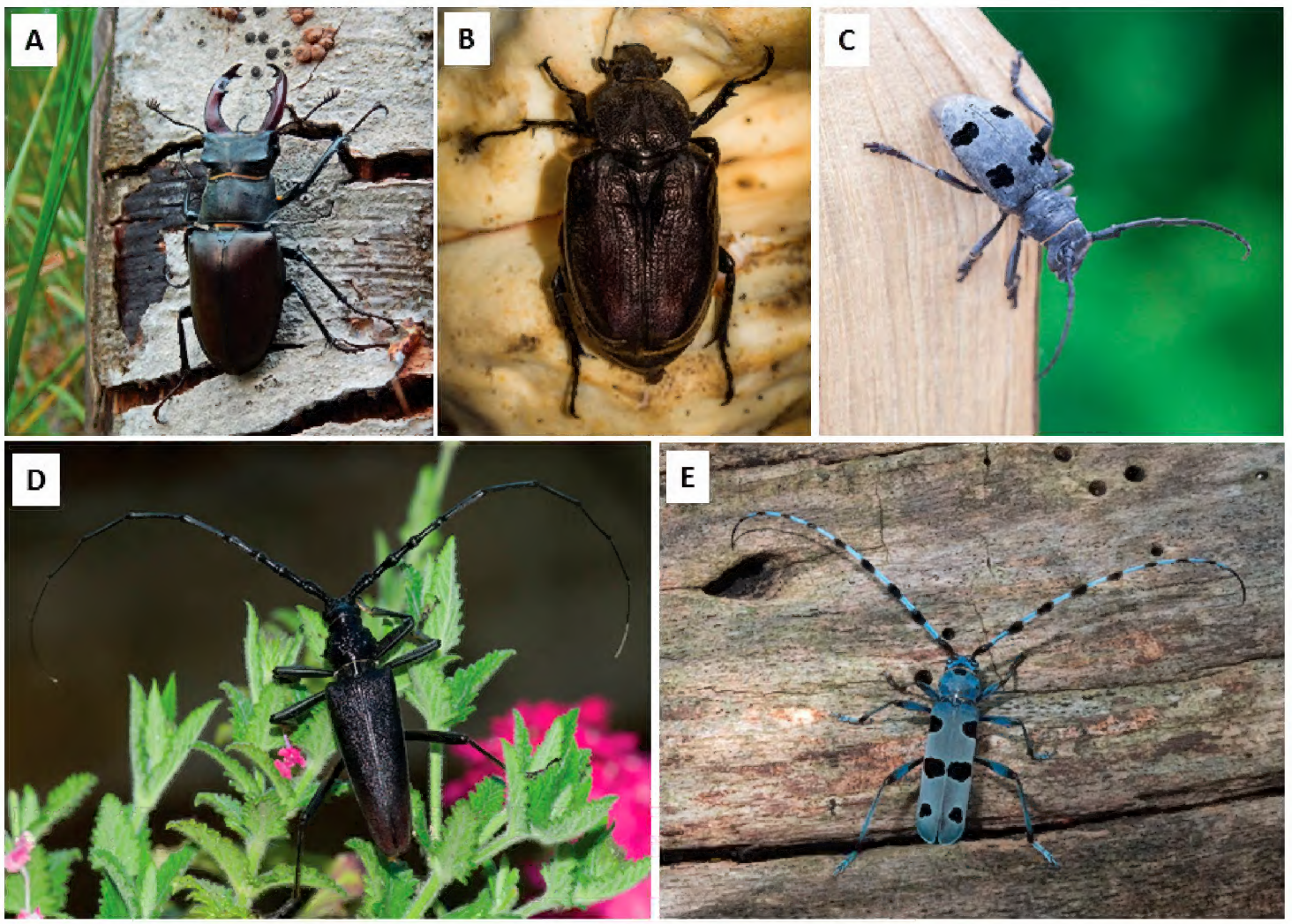

Figure 1. The target species of saproxylic beetles monitored by the Life MIPP Project. **A** *Lucanus cervus* (Photo by Fabio Garzuglia) **B** *Osmoderma eremita* (Photo by Francesco Lemma) **C** *Morimus asper funereus* (Photo by Kajetan Kravos) **D** *Cerambyx cerdo* (Photo by Elia Ferro) **E** *Rosalia alpina* (Photo by Sönke Hardersen).

ferent and representative micro-habitats of dead wood food-chains. These species are briefly introduced in the following.

Lucanus cervus (English name: European stag beetle): it lives in deciduous woodlands and flies at sunset. Larvae feed on dead wood in contact with the ground, e.g., under logs and stumps, or in senescent tree roots. Biology, ecology and monitoring methods of this species are treated in detail by Bardiani et al. (2017).

Osmoderma eremita (English name: hermit beetle) and its derived taxa: a typical inhabitant of old tree hollows. Larvae dig and feed into the walls of the cavities or in the wood mould settled at the bottom of the tree. The adult is very elusive. Biology, ecology and monitoring methods of this species are discussed in detail by Maurizi et al. (2017).

Cerambyx cerdo (English name: great capricorn beetle): nocturnal adults fly after sunset. Larvae live inside the decaying wood of large, old trees (especially oaks), often exposed to the sun. Biology, ecology and monitoring methods of this species are discussed in detail by Redolfi De Zan et al. (2017).

Rosalia alpina (English name: rosalia longicorn): diurnal adults often seen on the bark of old beech trees. Larvae typically develop in the wood of large beech trees often in other accompanying broadleaf species. Biology, ecology and monitoring methods of this species are discussed in detail by Campanaro et al. (2017a).

Table 2. Study areas where the monitoring methods were tested during the MIPP fieldwork.

Macro-areasand their acronyms	Physical geography	Administrative Region	Subareas (study sites)	Altitudem a.s.l.	Coordinates (Decimal Degrees)
Parco Naturale Regionaledelle Prealpi Giulie (PG)	Eastern Alps	Friuli-Venezia Giulia	Starmiza di Resia	750–850	46.3435-46.3414°N, 13.2994-13.3078°E
Bosco della Fontana (BF)	Po River Valley	Lombardia		19–25	45.2003°N, 10.7408°E
Bosco della Mesola (BM)	Po River Delta	Emilia-Romagna		0–2	44.8485°N, 12.2511°E
Foreste Casentinesi (FC)	Tuscan-Emilian Apennines	Emilia-Romagna	Rifugio La Lama and its surroundings	700–900	43.4312°N, 11.8381°E
		Toscana	Camaldoli	820–870	43.7874°N, 11.8208°E
Parco Nazionale d'Abruzzo, Lazio e Molise (PA)	South-central Apennines	Abruzzo	Difesa di PescasseroliVal Fondillo	1234–1352, 1090–1216	41.8461°N, 13.8600°E, 41.7841°N, 13.9563°E
			Zio Mas	ca 1030	42. 0802°N, 14.0566°E
			Feudo Intramonti e Colle di Licco	ca 1030	41.7818°N, 13.8974°E

Morimus asper funereus and *Morimus asper asper* (English name: morimus longicorn): originally only the first taxon had been included in Annex II of the Habitats Directive as a valid species (*Morimus asper*). A recent genetic study (Solano et al. 2013) suggests that all European populations of this genus should be referred to as *Morimus asper*, a genetically and morphologically variable species. Despite being unable to fly, this apterous species has unexpected dispersal ability. Larval development takes place in recently cut wood, stumps and trunks of damaged trees. Biology, ecology and monitoring methods of this species are discussed in detail by Hardersen et al. (2017).

Study areas

The methods for monitoring the target species were tested in five areas, mostly managed by CUTFAA. All areas investigated are an integral part of the Italian Natura 2000 network (SCIs and SPAs), and the data gathered represent an important contribution to the monitoring of the target species in Italy. See Table 2 for an overview of the study areas, their subdivision in subareas (study sites), with their geographic location, altitude and coordinates.

Parco naturale regionale delle Prealpi Giulie

The Parco Naturale Regionale delle Prealpi Giulie (=Julian Prealps Natural Park) covers 9,400 hectares and lies at the boundary between the Julian Alps and the Julian Prealps,

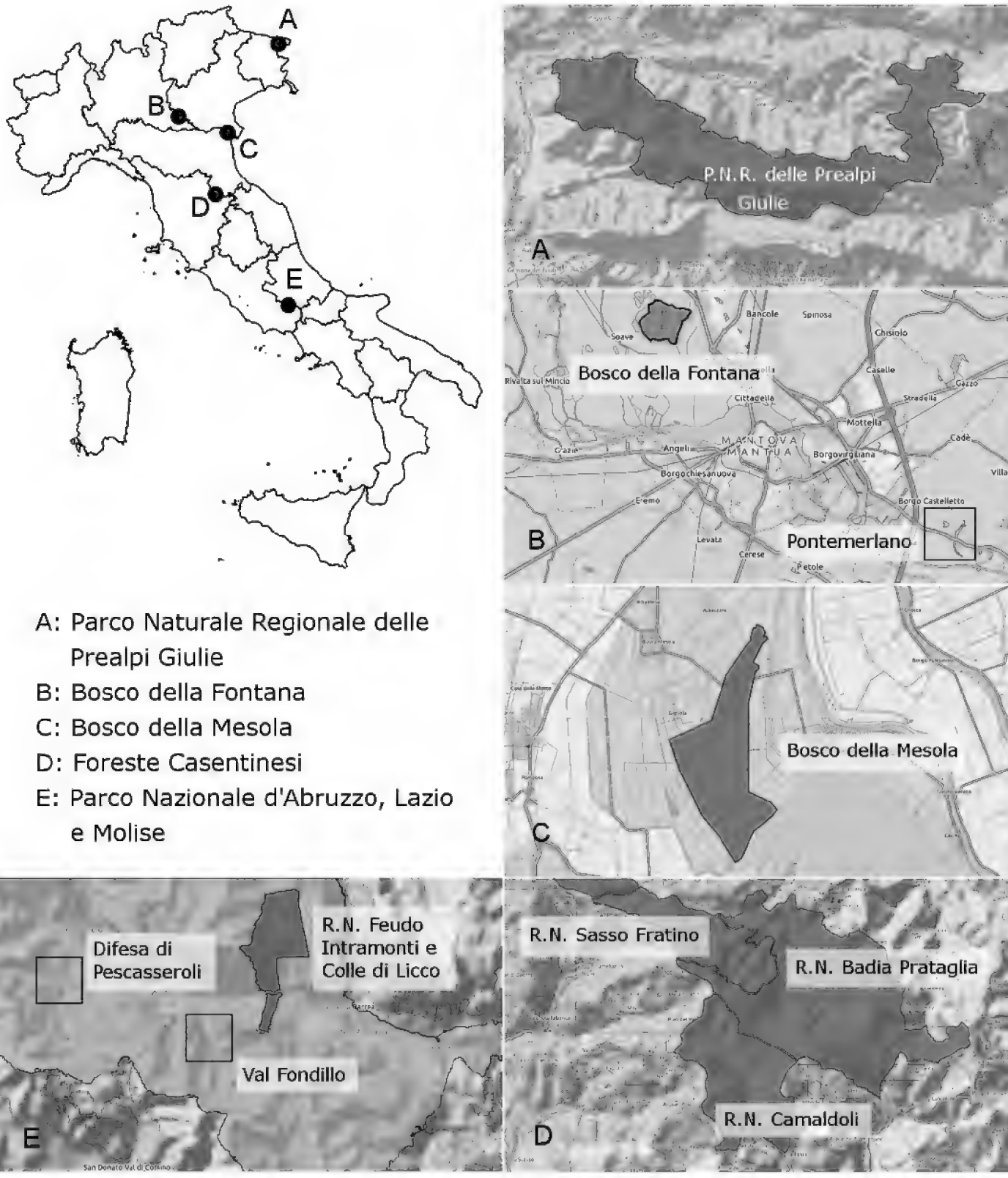

Figure 2. Location of the study areas and study sites used for monitoring the target species.

close to the Slovenian border. The park is a mountainous system which ranges from 300 to 2587 m a.s.l. and is divided into two main catchment areas. It is part of the two Special Areas of Conservation (SAC): IT3320012 (Prealpi Giulie Settentrionali) and IT3321002 (Alpi Giulie). Beech forests occur up to around 850 m a.s.l. and are replaced by *Pinus mugo* stands above 1400 m. The southern flanks of the mountains, characterised by poor soils and relatively high temperatures, are dominated by *Ostrya carpinifolia* and *Fraxinus ornus*. Other important formations present in the Park are forests of black pine (*Pinus nigra*) and Scots pine (*P. sylvestris*). The research for the MIPP project was carried out in the forest near to Starmiza di Resia (between 46.3435°N, 13.2994°E and 46.3414°N, 13.3078°E).

Figure 3. Parco Naturale Regionale delle Prealpi Giulie: young and even-aged beech trees, poor in dead wood. Wood piles were built for attracting *Morimus asper funereus* (Photo by Sönke Hardersen).

This area (750–850 m a.s.l.) is managed by shelterwood cutting and dead wood is removed. It resulted in young and even-aged beech trees and was poor in dead wood. However, owing to the local very steep morphology, dead wood occurs in small and isolated pockets of forests, favoured by limited accessibility or avalanches. Although the Park hosts populations of *Lucanus cervus*, *Rosalia alpina* and *Morimus asper funereus*, monitoring methods were only tested for the latter.

Bosco della Fontana

The Riserva Naturale Biogenetica Bosco della Fontana [=Bosco Fontana Nature Reserve] is located in the province of Mantova [Mantua], at an altitude of 19 to 25 m a.s.l. Bosco Fontana (45.200299°N, 10.740841°E) is a site of the Natura 2000 network (IT20B0011), managed by the Ufficio Territoriale Carabinieri per la Biodiversità di Verona [= Territorial Office of Carabinieri for Biodiversity of Verona]. It covers an area of 233 ha, of which 198 ha represent one of the last remnants of the ancient lowland broadleaf forests (with *Quercus robur* and *Carpinus betulus*) of the Po Valley (Mason 2002a). The reserve is an isolated forest patch, as the surrounding landscape has been significantly modified by human activities, including agricultural fields, rural settlements

Figure 4. Bosco della Fontana: large amount of dead wood due to special conservation management since 1992 (Photo by Sönke Hardersen).

and industrial buildings. The forest is dominated by pedunculate oak (*Quercus robur*) and hornbeam (*Carpinus betulus*), with a dense understory of hazel (*Corylus avellana*), hawthorn (*Crataegus laevigata*) and European spindle (*Euonymus europaeus*). In the northern part of the forest, the pedunculate oak is replaced by Turkey oak (*Quercus cerris*), while in the eastern part, southern ash (*Fraxinus angustifolia*) and black alder (*Alnus glutinosa*) are abundant. Between 1952 and 1958, allochthonous tree species (*Quercus rubra*, *Platanus* x *acerifolia*, *Juglans nigra*) were planted and the Life Project NAT/IT99/6245 initiated the elimination of the most invasive species, *Q. rubra* (Cavalli and Mason 2003, Mason 2003, Mason and Minari 2009). From the early 1990s, no wood has been removed from the forest and therefore the amount of dead wood increased: in 1995 it consisted of ca 26 m^3/ha on average (Mason 2002a) but locally reached 124 m^3/ha (Travaglini et al. 2007). Further information on management of the reserve are in Cavalli and Mason (2003), Mason et al. (2004), Campanaro et al. (2014). At Bosco della Fontana monitoring methods were tested for *L. cervus*, *C. cerdo* and *M. asper*.

Bosco della Mesola

The Riserva Naturale Bosco della Mesola [= Bosco della Mesola Nature Reserve] is managed by the Ufficio Territoriale Carabinieri per la Biodiversità di Punta Marina [= Territorial Office of Carabinieri for Biodiversity of Punta Marina] and covers an area of 1500 hectares. The Reserve, which is part of the Natura 2000 network

Figure 5. Bosco della Mesola: coastal lowland forest, where the abandonment of traditional management of the forest since the 1970s has resulted in an increase in dead wood (Photo by Gloria Antonini).

(IT 4060006) and of the Regional Park of the Po Delta, is located in the Province of Ferrara about 16 km from the Adriatic coast. This forest is a coastal lowland woodland of high importance for conservation, dominated by holm oak (*Quercus ilex*) and pedunculate oak (*Quercus robur*). Other important tree species occurring in the area are hornbeams (*Carpinus betulus* and *C. orientalis*), ashes (*Fraxinus angustifolia* and *F. ornus*), poplars (*Populus alba*, *P. tremula*, *P. nigra*) and field elm (*Ulmus minor*). The understory is scarce and the most abundant species are common hawthorn (*Crategus monogyna*) and wild privet (*Ligustrum vulgare*). Between 1945 and 1971, non-native trees were planted, such as stone pine (*Pinus pinea*) and maritime pine (*Pinus pinaster*). The abandonment of traditional management of the forest since the 1970s has resulted in an increase in dead wood which is now very abundant. The research conducted during the MIPP project in the Bosco della Mesola (44.8485°N, 12.2511°E) was focused on testing the monitoring methods for *C. cerdo* and *M. asper asper*.

Foreste Casentinesi

The Foreste Casentinesi [Casentine Forests] are natural and historical forest areas located in the Tuscan-Emilian Apennines, within the Parco Nazionale delle Foreste

Figure 6. Foreste Casentinesi: old chestnut orchards where a population of *Osmoderma eremita* was discovered for the first time by the MIPP researchers (Photo by Sönke Hardersen).

Casentinesi, Monte Falterona e Campigna [= Foreste Casentinesi, Monte Falterona and Campigna National Park]. The research was carried out in two areas managed by the Ufficio Territoriale Carabinieri per la Biodiversità di Pratovecchio [= Territorial Office of Carabinieri for Biodiversity of Pratovecchio]: the Lama Forest and adjacent zones which are part of the Natura 2000 network (IT 4080001) and the chestnut stand Foreste di Camaldoli, Badia Prataglia (IT 5180018). The core area of the Casentine forests is the area of Sasso Fratino (764 ha), where cuts have been abandoned for more than 100 years. This forest is amongst the most natural woodlands of western Europe and consist of beech woods, mixed stands of silver fir and beech, and mixed deciduous broadleaf forests. Beech forests are widespread in the Park from 600–700 m up to 1,700–1,800 m a.s.l. Although their composition varies with altitude, they are mostly dominated by beech (*Fagus sylvatica*) and harbour a number of associated trees such as sycamore maple (*Acer pseudoplatanus*), European ash (*Fraxinus excelsior*), whitebeam (*Sorbus aria*), alpine laburnum (*Laburnum alpinum*) and rowan (*Sorbus aucuparia*). The mixed deciduous broadleaf forests are widespread throughout sub-montane areas and represent the most diverse tree association of the Apennines, with various combinations of manna ash (*Fraxinus ornus*), Turkey oak (*Quercus cerris*), downy oak (*Quercus pubescens*), Italian maple (*Acer opalus*), Norway maple (*Acer platanoides*), European hop-hornbeam (*Ostrya carpinifolia*), large-leaved lime (*Tilia platyphyllos*), com-

Figure 7. Foreste Casentinesi: natural beech forest where three target species were monitored, *Lucanus cervus*, *Osmoderma eremita* and *Rosalia alpina* (Photo by Sönke Hardersen).

mon laburnum (*Laburnum anagyroides*), wild cherry (*Prunus avium*) etc. Finally, near to human settlements, e.g. near the Monastery of Camaldoli, there are some very old stands of *Castanea sativa* which are managed as coppice or chestnut orchards. The

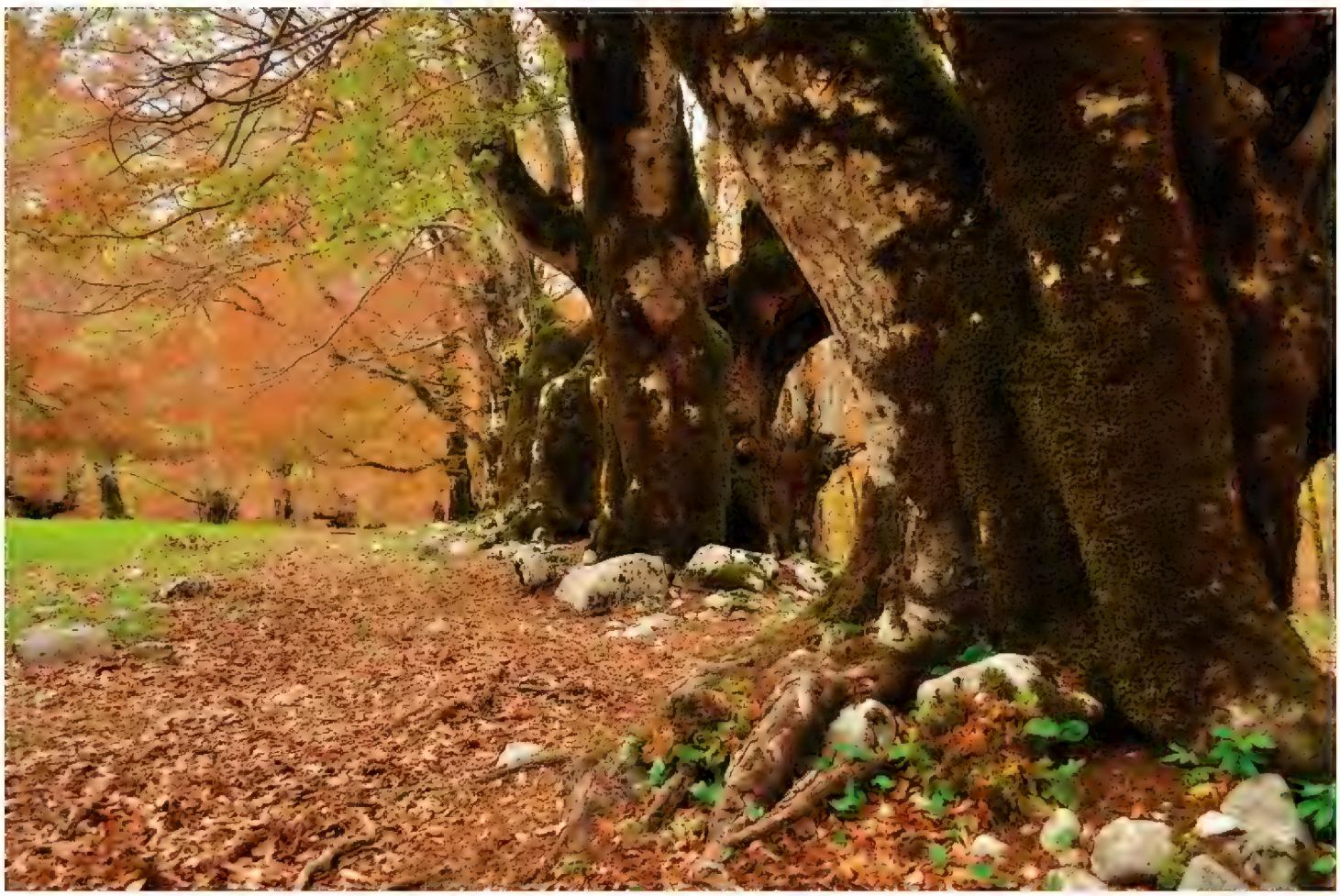

Figure 8. Parco Nazionale d'Abruzzo, Lazio e Molise: old growth beech forests where monitoring methods were tested for both *Osmoderma eremita* and *Rosalia alpina* (Photo by Emilia Capogna).

Forests of the Park are home to at least four species of saproxylic beetles investigated by the project: *L. cervus*, *O. eremita*, *R. alpina* and *M. asper asper*. Monitoring methods were tested only for the first three species in the transitional belt between beech forest and mixed deciduous broadleaf forest, at an altitude of 700 to 900 m a.s.l., in several sites around the Lama Forest refuge (43.4312°N, 11.8381°E), i.e. Poggio Ghiaccione, Poggio Piano, La Vetreria, and the road to Badia. Only *O. eremita* was also monitored in the old chestnut orchard near to Camaldoli (43.7874°N, 11.8208°E) at an altitude of 820–870 m a.s.l.

Parco Nazionale d'Abruzzo, Lazio e Molise

Within the Parco Nazionale d'Abruzzo, Lazio e Molise [=Abruzzi, Lazio and Molise National Park], centred in the southern part of the Abrutian Apennines, surveys for the MIPP project have been carried out at four sites: "Difesa di Pescasseroli" (41.8461°N, 13.8600°E), "Val Fondillo" (41.7841°N, 13.9563°E), "Riserva Naturale Orientata Feudo Intramonti e Colle di Licco" (41.7818°N, 13.8974°E) and "Zio Mas" (42. 0802°N, 14.0566°E). The first two areas (Difesa di Pescasseroli and Val Fondillo) are managed by the Park, while the other two (Zio Mas and Feudo Intramonti) are run by the Ufficio Territoriale Carabinieri per la Biodiversità di Castel di Sangro [= Territorial Office of Carabinieri for Biodiversity of Castel di Sangro] (province of L'Aqui-

la). Difesa di Pescasseroli and Val Fondillo are located near Pescasseroli (province of L'Aquila), at an altitude of 1234–1352m and 1090–1216m respectively and consist of a mosaic of mature and old-growth forests dominated by beech (*Fagus sylvatica*) and its associated tree species, such as sycamore maple (*Acer pseudoplatanus*), European ash (*Fraxinus excelsior*), whitebeam (*Sorbus aria*), hornbeam (*Carpinus betulus*), yew (*Taxus baccata*) etc. Beech forests cover more than 60% of the Park surface and harbour very old trees, due to the limited accessibility of some steep mountainsides or to the presence of nature reserves where all exploitation of resources is strictly forbidden. Zio Mas and Feudo Intramonti e Colle di Licco are located at an altitude around 1030 m, near to Casone Crugnale, in mesophilous deciduous forests. Monitoring methods were tested only for *O. eremita* and *R. alpina*.

Developing the methods for monitoring

In order to develop and test the most appropriate monitoring methods, all relevant literature was reviewed in order to select the most suitable approaches to be tested for the monitoring of the target species. In Action A1 of the project MIPP, these methods were critically reviewed and the reviews were sent to 15 experts from other European countries for critical examination. Comments were received from renowned specialists and their advice considerably improved the reviews. Based on these documents, a work plan was developed for the years 2013–2017 in collaboration with the Region Lombardy (Action A2) and the appropriate statistical approaches were selected. It became obvious that the suitability of the statistical approach was influenced by many variables, e.g. local population structure. Whereas an abundant and evenly distributed population of *M. asper* at Bosco della Fontana allowed the adoption of an approach based on randomisation, a clustered population structure, as observed in the Julian Prealps, called for a randomised block design. The target parameters to be monitored were always the number of individuals detected in relation to a given effort. It has been shown that such counts are often highly correlated with estimates of population sizes in insects (e.g. Dolek and Geyer 2000, Collier et al. 2008). The correlations between the number of individuals observed and environmental parameters were also considered, with the aim of providing practical indications for the monitoring (i.e. temperature, tree-diameters, time of the year). Generally, the methods chosen were based on the means by which the target species could be attracted or situations where/when individuals naturally occur at higher densities. When monitoring rare or cryptic organisms, the use of attractants can help to increase detection rates (e.g., Larsson and Svensson 2011, Ray et al. 2009). For example, adults of *O. eremita* are attracted by the pheromone (R)-(C)-γ -decalactone (Larsson et al. 2003) and adults of *M. asper* by freshly cut wood (Chiari et al. 2013a). An example for one of the target species naturally occurring at higher densities is the 30 minute period around sunset between 18 June and 8 July for *L. cervus* (Campanaro et al. 2016). A further important point was that the methods to be tested did not kill or harm the insects. Therefore, traps were intended to

catch live adults of the target species and were checked daily; the insects caught were carefully handled and quickly released. The methods selected for each species were applied in at least two study areas and were carried out for a minimum of three seasons.

The large amount of field work carried out for the development of the monitoring methods was only possible because many people helped the project staff. Many field assistants from various countries joined the team during the field work. A total of 10 Theses for Bachelor, Master and PhD degrees (see names in Acknowledgements) were written in collaboration with the project MIPP, the contribution by some of these students being crucial for the field work as well. The final aim of the fieldwork was to develop methods which ensure scientific validity, ease of execution and low cost. Obviously, the methods published are compromises as, particularly for small populations, it is difficult to balance limited labour costs and high detection probability. The results of the field work were analysed statistically, with a large variety of approaches, always with the aim of comparing the different methods tested and defining the best possible monitoring method.

A special permit was obtained from the Italian Ministry of Environment for handling and capturing individuals of the target species (collection permit: Ministero dell'ambiente e della Tutela del Territorio e del Mare – DG Protezione della Natura e del Mare, U.prot PNM 2012-0010890 del 28/05/2012).

Methods tested for the MIPP project

Different methods have been used for either detecting the target species (to assess their presence in the areas) or monitoring their populations (to develop a suitable technique for non-expert operators).

L. cervus was counted along 500m linear transects at dusk (15min before and after sunset), using both sightings and net captures in two study sites, Bosco Fontana and Foresta della Lama. At Bosco Fontana, stag beetle remains from bird predation were collected by day along transects, while aerial traps, baited with wine and/or beer with sugar or banana juice, were set in trees at different heights from the ground. Details on methods are reported by Bardiani et al. (2017a, 2017b).

Osmoderma eremita was lured by pheromone traps (BCWT) and unbaited pitfall traps (PT) in three study sites of the Abruzzi, Lazio and Molise National Park (Difesa di Pescasseroli, Val Fondillo and Feudo Intramonti- Colle di Licco) and in two sites of the Casentine Forests (Lama Forest and Monastery of Camaldoli). Larvae were searched for with the aid of the trained dog (Osmodog subproject) in several sites of all macro-areas. Details on methodologies are reported by Maurizi et al. (2017).

Cerambyx cerdo was monitored in Bosco della Fontana and Bosco della Mesola, by four methods: using attractant for adults i.e. ash sap in feeding stations on trees; setting aerial traps baited with fermented mixtures of wine, beer, banana or sugar; detecting the adults during Visual Encounter Surveys (VES); and collecting remains along transects. Details on methods are reported by Redolfi De Zan et al. (2017).

Rosalia alpina was monitored in several beech forest sites of the Foreste Casentinesi and of Abruzzo, Lazio and Molise National Park. Methods consisted of detecting adults during visual surveying of single logs or groups of logs; and searching on artificial tripods made from beech woods. Trees were considered suitable for these beetles when characterised by the presence of dead wood on the trunk and exposed to direct sun light for at least 1–2 hours. Logs consisted of beech trunks with diameters of 28–75cm. Tripods consisted of 3 beech logs (diameters 20–25cm) and were placed in open areas with easy access (along forest roads or clearings) at a minimum distance of 30m from each other. Details on methodologies are reported by Campanaro et al. (2017a).

Morimus asper was monitored in the Julian Prealps (*M. asper funereus*) and Bosco della Fontana (*M. asper asper*) by using freshly cut log piles and pitfall traps baited with chemical compounds. Between 2014 and 2016, the influence of the characteristics of logs (e.g. diameter, age of wood, tree species) on the number of adults observed has been evaluated. Additionally, the attraction of chemical compounds for the species was assessed. Details on methods are reported by Hardersen et al. (2017).

Faunistic data were collected with the Citizen Science action developed within the LIFE MIPP Project using a website and an app for mobile devices, with an attempt being made to involve the highest number of persons possible. All data were validated by experts, based on pictures taken by citizens.

Osmodog: training a dog for searching *Osmoderma eremita*

The dog, a Golden Retriever named "Teseo", was chosen from a stock selected for the CITES Service of the former CFS (today: CUTFAA) and trained under the supervision of experienced staff. Originally, it was hypothesised to exploit the fact that males of *O. eremita* release large quantities of a sex pheromone which even humans can smell. However, after consulting with the Department of Forest Protection of the Austrian Research Centre for Forests, which has for many years trained scent detection dogs for the longhorn beetle *Anoplophora glabripennis*, it was decided to focus the training on the larvae of the hermit beetle. The reasons for this decision were: 1) Larvae of saproxylic beetles have a species-specific scent (Hoyer-Tomiczek et al. 2016), even though it cannot be smelt by humans; 2) Larvae of *O. eremita* are present all year round whereas the adults only occur from June to September; 3) Only larvae reliably indicate trees in which the species reproduces, as adults can fly up to 1.5km (Chiari et al. 2013b). Teseo started working with its trainer at the age of 6 months and actual fieldwork was carried out once the dog had reached adulthood (24 months). To imprint the target odour on the dog, a hermit beetle larva was kept in a box filled with wood mould collected from a tree. During the initial trials, the larva was washed with water and kept in a perforated box. When the dog had learned to recognise the target odour, the training continued by hiding the boxes (full and empty) inside basal cavities of trees and other microhabitats within a fenced training area. This training phase ended when Teseo had

Figure 9. The trained dog searching for hermit beetles with his handler (Fabio Mosconi) in the old growth forest of Difesa di Pescasseroli (Photo by Emanuela Maurizi).

successfully learned to locate and signal the target to the trainer. The accuracy of Teseo was measured in eight wooded areas by two different approaches. The first set of tests was carried out in six sites without populations of hermit beetle which did however contain hollow or fractured trees suitable for its larvae. Further tests were based on filters soaked with the larval odour, hidden in randomly chosen trees by a field assistant unbeknown to the dog and to the handler. During the search sessions, the handler reported on the behaviour of the dog to a field assistant by assigning a score to the dog response: no reaction, partial signalling and complete signalling. Details on the methods are giving by Mosconi et al. (2017).

Results and discussion

Monitoring the target species

For each target species, the MIPP research staff identified a monitoring method judged to be the "best method" for detecting changes in occurrence and abundance of a population over time, according to the following criteria: scientific validity, high number of detected or captured individuals, ease of execution, low level of invasiveness and low cost.

For *Lucanus cervus*, the selected method consisted of walking at dusk, along a standard length transect (500m long and 10m width) and counting all adults of stag beetles seen flying or walking on the ground. This transect walk was carried out by one operator, from 15 minutes before sunset to 15 minutes after sunset. Overall, a transect walk lasted 30 minutes. The transect was divided into 5 sectors of 100 m; each sector had to be walked in 6 minutes. Transects were chosen along forest paths, tracks or roads with acceptable light conditions at dusk and with a suitable canopy openness. Details on the method are reported by Bardiani et al. (2017).

For *O. eremita*, the selected method for monitoring was based on black cross window traps (BCWT) baited with the sex pheromone of the species and hung on tree branches. Traps had to be checked every second day to prevent the animal from dying. In order to minimise disturbance of reproductive activity and behaviour, this monitoring was undertaken no more frequently than every three years. As an alternative method, a high number (at least 150) of pitfall traps (PT) could be placed into the same number of tree cavities. Although this method is cheaper and less invasive (as no pheromones interfere with the breeding activities), it may be used only in areas where tree hollows are very abundant and rich in wood mould. Additionally, the team needed to be composed of several people in order to ensure the checking of so many traps every two days. Details on traps and problems related to the sampling methods of this elusive species are reported by Maurizi et al. (2017).

For *C. cerdo*, the selected method is the use of purpose-made aerial traps composed of two stacked plastic containers embedded together one above the other with a wire insect net between them. Traps should be positioned on tree branches (especially oaks with a diameter larger than 50cm), at a height of 10m above ground and baited with

red wine, white wine and sugar. Ten traps were positioned in each sampling area and needed to be checked every day. Details on traps and protocol are reported by Redolfi De Zan et al. (2017).

For *R. alpina*, the selected method consisted of surveying 15 beech trees with a large diameter (over 30cm), dead or rich in deadwood and exposed to the sun, these being the natural breeding habitat of the species. The results showed that the use of artificial wood baits (tripods) or logs specifically placed for monitoring did not represent practical alternatives. Details on results are reported by Campanaro et al. (2017a).

For *M. asper*, selected method consisted of building and checking freshly cut wood piles which functioned as an attractant for the adults of this species. Each pile was built from single tree species, using wood with a diameter larger than 12cm. The tree species used for building the piles needed to be chosen carefully and the preferred trees seemed to be hardwood species such as beech and oaks. Details on results are reported by Hardersen et al. (2017).

Citizen science

A total number of 2,308 records were transmitted to the project database by a total of 695 citizens. The high rate of correct validations (73%) confirmed that the majority of the data collected by volunteers was correct. The number of annual records constantly grew from 2014 to 2016 as did the number of participants. The species most commonly recorded was *L. cervus*, followed by *M. asper* and *R. alpina*. The records, collected by the citizen science approach, allowed detailed analysis of altitudinal distribution and phenology of the target species, particularly for those with the highest numbers of records. These data were in line with the phenology and altitudinal distribution published by authors of scientific publications on the subject. For four species it was also possible to analyse how phenology changed with increasing altitude and it was found that peak activity was delayed by 10 days on average when moving 400m upwards.

Osmodog

For each field session, the dog was able to work for about 50 minutes, after which it needed to rest for 15 to 60 minutes before restarting its work. High temperatures caused a general decrease in the dog's working ability. At the end of the training, Teseo learnt to signal exclusively for the larvae of *O. eremita* even though it sometimes showed some faint reactions to the larvae of other species such as *Oryctes nasicornis* and *Gnorimus variabilis* (e.g., by sitting adjacent to the source of the odour or barking weakly). The results of the tests showed that the use of a trained dog to find hermit beetle larvae is better than the traditional wood mould sampling. In fact, the dog showed a higher degree of success in detecting colonised trees (over 70%) in two ar-

eas formerly checked with wood mould sampling (up to 50%) (Chiari et al. 2014). Furthermore, the use of a dog was much less time consuming than wood mould sampling: Teseo, during a day with good weather conditions, was able to detect larvae of *O. eremita* with high accuracy and employed less than one tenth of the time needed for wood mould sampling. In addition, the use of a dog eliminated the risk of harming larvae and the fragile equilibrium of its microhabitat where a whole biocoenosis of saproxylic organisms occurs.

Dissemination of knowledge and communication

Participation by children in environmental education programmes seems to have a great impact on their attitude and behaviour. Some studies have shown that children who participate in such programmes are more concerned about nature, want to learn more about environmental issues and are more prone to follow pro-environmental behaviour (e.g. waste recycling) than children who did not participate (see Wells and Lekies 2012, for a review). The MIPP actions focused on Dissemination and Communication, to inform the public on issues such as Natura 2000, the Habitats Directive, monitoring activities, the forest ecosystem and the ecological role of the saproxylic insects. These actions involved a large variety of media and approaches: radio-television programmes, press releases, interviews, articles on nature magazines, stories in newspapers, school lessons, presence at fairs, public lectures, creation of comic strips, leaflets, posters, etc. The dog trained to monitor the hermit beetle, was also used as a "curiosity" factor to attract public attention toward the rare beetle and the issues mentioned above. For example, the dog was used as the principal character in the brochure "Osmodog and the small forest dwellers" [Italian title: Osmodog e i piccoli abitanti delle foreste), intended for school children (it can be downloaded free at: http://lifemipp.eu/mipp/data/download/Osmodog.pdf).

In the MIPP project, a specific education activity, named "MIPP-iacciono gli insetti" [literal translation: I like insects] for young people from primary to high school, was developed and carried out in several regions of Italy. One of the objectives of the project was to perform 60 activities (lessons) per year and involve 3000 students. The aims of the activity were to disseminate information related to the protection and conservation of old forest and dead wood and to allow children to learn about saproxylic insects. "MIPP-iacciono gli insetti" started with an interactive discussion stimulated by a variety of pictures of old and artificial forests, dead wood and saproxylic insects. After this, children were encouraged to learn how to identify the target insects of the MIPP project, by using their sense of hearing, sight and smell. In particular, during the game of "smell" they impersonated Teseo, the dog, by sniffing a series of smells and guessing that of *Osmoderma eremita*.

Other educational activities for young people from primary to high school performed during the MIPP project included guided tours in natural reserves, where particular attention was paid to old forests, dead wood and saproxylic insects.

Figure 10. Dissemination activities with children: digging into dead wood and handling beetles (Photo by Michela Maura).

Concluding remarks and recommendations

The Life Project MIPP was a challenge from many points of view: collaborating between different institutions, coordinating a large amount of field work in five study

Figure 11. Dissemination activities in primary school: a field trip together with MIPP researchers (Photo by Emanuela Maurizi).

areas, developing monitoring methods for cryptic and elusive species, organising a citizen science project to increase the knowledge on the distribution of rare and protected insects, educating people on biodiversity and Natura 2000 and on the importance of veteran trees in forest ecosystems, etc. Due to the goodwill and hard work of many people, obstacles and hurdles were overcome and the project managed to complete all planned actions successfully. The articles in this special issue provide the scientific results on testing monitoring methods and the detailed presentation of the method which resulted in being the most appropriate in terms of costs and accuracy for monitoring the conservation status of the five saproxylic beetles targeted by the project. Two of these articles have been dedicated respectively to the successful results of two subprojects: the citizen science and the training of a dog for detecting *O. eremita* in the field.

The results on monitoring methods showed that the management authorities can be able to provide the six-year report requested by the Habitats Directive on the five saproxylic species listed in the Annexes, by means of simple, efficient and low cost methods and procedures. Moreover, they can easily obtain the help of Master's students and PhD scholars from several universities where saproxylic insect ecology is the subject of local research groups. A 'symbiotic relationship' or simply mutual support can be developed between research institutions and conservation authorities with reciprocal benefits. Many students and scholars are available to work for free in monitoring threatened species in order to get data for their theses, vocational training, internship at a protected area or research project. The management authorities can provide these helpers with logistical support, e.g., transportation inside the protected area on off-road vehicles (if necessary), rangers as guides, accommodation in refuges or local

guest-rooms. Simple and basic cottages with bunk beds for scholars and volunteers should be one of the first actions to be made for improving scientific research and monitoring in a protected area. With regards to the use of the data collected every year on the populations of the target species (i.e. number of specimens recorded in each area by each method per day/week/month/total), each country should delegate a ministerial office or other governmental agency to gather this precious information in a simple database and this should be published on line, in an official site, with access reserved for the scientific community.

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